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ORGANISMS CAUSING BENEFICIAL ROOT GALLS

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In North America, there are over 2000 different species of plants and animals capable of modifying the physiology of root cells and causing swellings or overgrowths known as galls (2). Certain genera of nematodes are widely recognized as organisms capable of causing severe root-galling and subsequent substantial crop losses. In addition to nematodes, certain viruses, bacteria, actinomycetes, fungi, algae, and insects may cause root-galls. Many of the gall forming organisms are beneficial to their hosts, and these will be discussed.

Three types of organisms cause beneficial galls or specialized root structures called nodules. Within these galls, the organisms live symbiotically and fix atmospheric nitrogen during a defined part of their life cycle. These three types of organisms are bacteria belonging to the genus Rhizobium, actinomycete-like organisms belonging to the genus Frankia, and blue-green algae belonging to the genus Nostoc (1).

Bacterial Symbiosis: Rhizobium species are able to grow and reproduce independently in the soil, but in natural conditions their nitrogen-fixing activity is restricted to associations with the roots of higher plants. Most of these associations occur in about 1100 species in the family Leguminosae (1). Common agricultural plants on which Rhizobium-caused nodules can be observed are beans, peanuts, soybeans, cowpeas, clover, and alfalfa. Atmospheric nitrogen that is fixed by bacteria is transferred to the legume host plant in sufficient quantities to supply the basic needs that these plants have for nitrogen during most of their growth and development. In fact, the use of moderate to high quantities of fertilizer containing nitrogen will inhibit the formation of nodules by Rhizobium species on legumes.

Although the occurrence of Rhizobium-caused nodulation is mostly restricted to legumes, it may also occur on non-leguminous plants. Nitrogen-fixing symbiosis occurs between Rhizobium sp. and a non-leguminous tree belonging to the genus Trema (Ulmaceae) (1). There are about 30 species of the genus Trema distributed in tropical and subtropical regions, mainly in Eastern Asia.

Actinomycete symbiosis: At least 137 species of angiosperms are reported to have root nodules with actinomycete-like organisms that are associated with nitrogen fixation. Most of these are non-leguminous, woody shrubs and trees belonging to the genera Alnus, Casuarina, Ceanothus, Coriaria, Elaeagnus, and Myrica (1,4). Nodules caused by actinomycetes typically occur in clusters. This may be readily observed on the roots of Elaeagnus species (Fig. 1). In Alnus species, some of these clusters may reach the size of a tennis ball. In Casuarina species (Australian pine), an interesting modification of root growth occurs in host roots emerging from the nodules. These roots, characteristically, begin to grow upward instead of turning downward in the normal geotropic response (1).

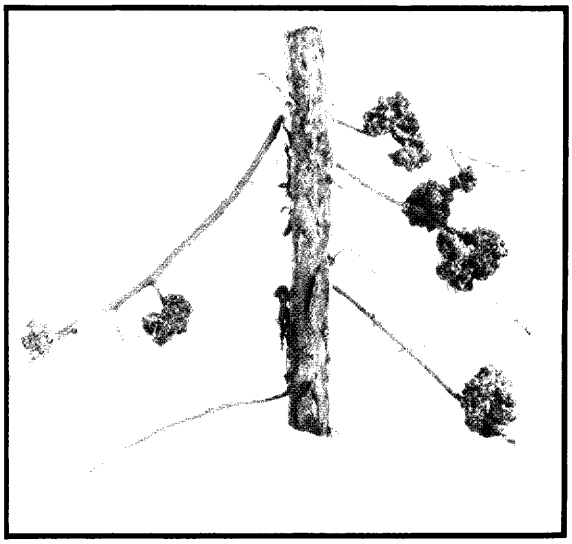

Fig. 1. Roots of Elaeagnus pungens Thunb. with clusters of galls caused by an actinomycete. (Photo credit: DPI #702848-11, J. Windsor)

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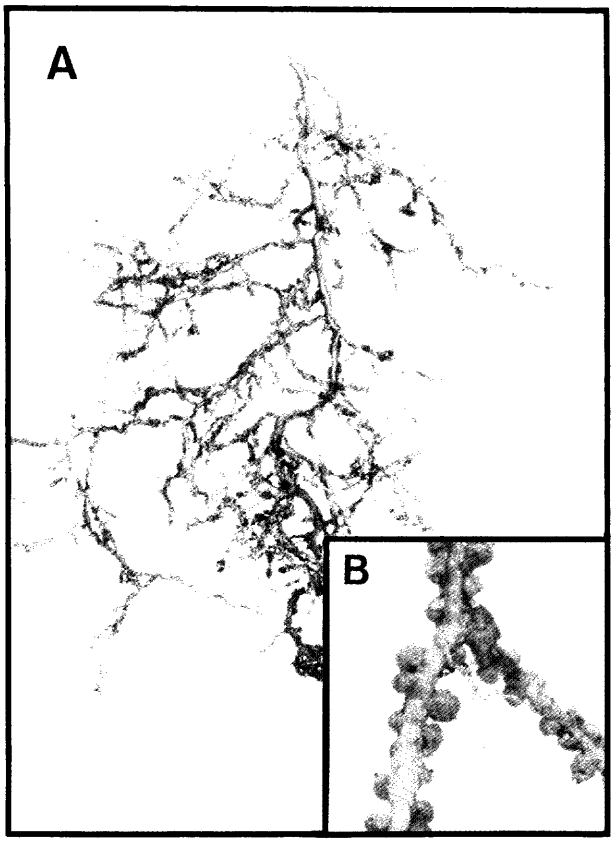

Fig. 2. Portions of Podocarpus macrophyllus roots with bead-like galls. A) General aspects. B) Closeup as galls may appear with hand lens. (Photo credit: DPI Photo #702848-5 and #702484-8, J. Windsor)

Most of the woody shrubs and trees that are hosts for actinomycete nitrogen fixation are primary colonizers of nitrogen-poor soils. This is especially true in high latitude areas of Europe and North America, where the alder tree, Alnus species, and, to a lesser extent, Dryas and Myrica species are dominant plants in glaciated soils that are low in nitrogen.

Blue-green algae symbiosis: The blue-green algae are the only group of organisms that can fix significant amounts of atmospheric nitrogen symbiotically as well as non-symbiotically. This symbiotic fixation is restricted to the roots of gymnosperms, primarily cycads. In these plants the nodules originate from specialized roots called coralloid roots, which show typical nodule-like structures even before being invaded by blue-green algae. At least 34 species of cycads, from the genera Bowenia, Ceratozamia, Cycas, Dioon, Encephalartos, Macrozamia, Microcycas, Stangeria, and Zamia have nodules with blue-green algae capable of fixing nitrogen which is then transported to the symbiont host plant.

The galls that occur on the roots of Podocarpus species appear to be an exception to the common symbiotic association of blue-green algae with gymnosperms. Bead-like galls normally cover a high percentage of the root surface of Podocarpus macrophyllus (Thunb.) D. Don, (Fig. 2A, B). The symbiont in galls or nodules of this plant is a primitive fungus (phycomycete) that occurs intracellularly in the cortex (4). The role of this organism in the host plant roots remains poorly understood, but there is evidence that nitrogen fixation is minimal, outside of that which occurs through bacterial associations in the rhizosphere (3,4).

Survey and Detection: The galls or nodules caused by beneficial organisms are generally more easily detached from host roots than are root galls caused by nematodes. In Florida, beneficial nodules can readily be observed on plants of the genera Podocarpus, Elaeagnus, Cycas, Casuarina, and on many species of legumes.

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